

Water Quality Changes in River Nile Cairo, Egypt.

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Abstract: A study of the water quality changes of River Nile were conducted from July 2007 to January 2009. The study is carried out at six sites along the River Nile, at Cairo district. A total of 23 water quality parameters were measured according to standard methods such as temperature, pH, DO, TDS, turbidity, chlorophyll "a" content, algal counts. The statistical evaluations were also done using regression coefficient. The result of statistics analysis showed that positive correlation of algal count with temperature ($r = +0.73$), pH ($r = +0.65$), turbidity ($r = +0.49$), DO ($r = +0.42$), NO₃ ($r = +0.54$) and phosphate ($r = +0.31$). However, the analysis revealed that most of the water samples were below or limited; according to the WHO standard of surface water.

Key words: River Nile water, physico-chemical, biological, statistical, water quality, Regression Coefficient.

INTRODUCTION

River Nile is the main source of potable water for Egypt. The River Nile water after High Dam construction generally is held long enough to permit significant changes in physical, chemical and biological characteristics of water^[1-4]. The disposal of industrial and domestic effluent has led to elevated concentration of phosphate and nitrate dissolved in water body, and thereby stimulated algal growth^[5].

Physical factors that influence the type and numbers of phytoplankton in River are flow rate, water level, light, temperature and turbidity. Biologically, temperature and solar radiation occupy an important role in the control of planktonic life. Temperature changes not only affect physiological processes of cells, but also influence the kind of life that present in water. Garret *et al*^[6] found that temperature was the major factor influencing both algal growth and phosphorus removal.

They are an excellent ecological indicator at the species level, sensitive to a number of environmental variables including light, temperature, inorganic nutrients (carbon, phosphorus, nitrogen, silica, and iron), organic carbon, organic nitrogen, oxygen concentrations, pH, salinity^[7]. Also, communities in stream is conditioned by others factors such as the nature of the substrate where they develop^[8]. Current velocity^[9&10], nutrient concentrations^[11&12] and temperature^[13&14] within the aquatic environment.

There for, the aim of this study is:

To determine the changes of the Nile water quality in association to the seasonal variation and other activities occurring at the River Nile.

MATERIALS AND METHODS

1-Sampling Site: Study area of the River Nile is located in Cairo district along ≈ 45 Km. Six sampling sites were chosen (Fig. 1), El-Shobak (H₁), in front of Iron and Steel Factory (H₂), intake of Kafer El-Elow water works (H₃), intake of El-Fostate water works (C₁), intake of El-Giza water works (C₂) and intake of Rod El-Farag water works (C₃).

2-Water Analysis: Water samples were collected at monthly intervals of a period (July 2007- January 2009). Determinations of the physico-chemical characteristics involves the temperature, pH, turbidity, electric conductivity (EC), total dissolved solids (TDS), dissolved oxygen, total alkalinity, sulfate, ammonia, nitrite, nitrate, total organic nitrogen, silica, iron and manganese. The Standard Methods, recommended by the APHA^[15] was followed.

3- Phytoplankton Parameters: Enumeration of phytoplankton, quantification of chlorophyll "a" concentration and phytoplankton accomplished according to APHA^[15&16].

4- Statistical Analysis: Statistical analysis was established applying regression coefficient according to^[17&18].

RESULTS AND DISCUSSION

Physicochemical Characteristics of Nile Water: Results of physico-chemical characteristics of Nile

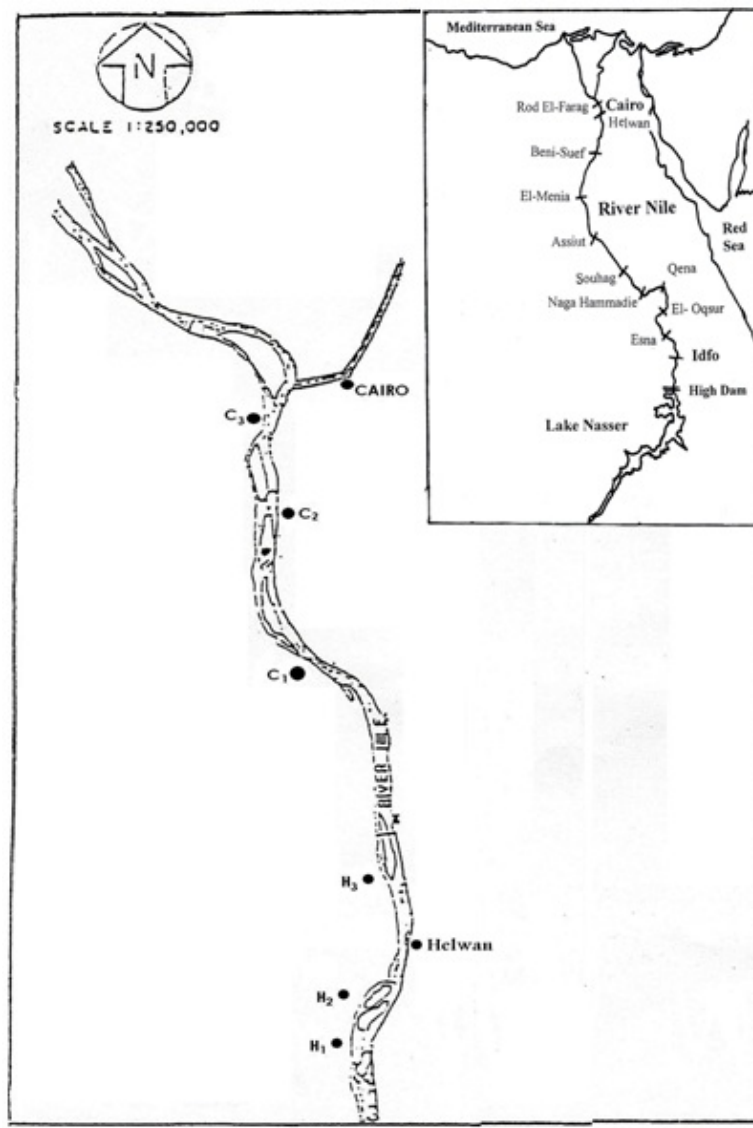


Fig. 1: Location map of the River Nile showing sampling sites.

water during the investigated period showed no clear variation between different months or between different sites along the river (Table 1) as follows:

1-Temperatures: Temperature fluctuated from 17-30 °C in each study months. The high temperature influenced the photosynthetic activity of the phytoplankton, especially during summer and fall seasons when concentration of chlorophyll "a" reached a maximum (Fig 2). Correlation analysis showed that temperature has a high negative correlation with

dissolved oxygen ($r = - 0.88$) while positive correlation with pH, nitrate, phosphate and phytoplankton took place (Table 2 and Fig. 3). It may be shown that, water temperature play an important role in the concentration of DO. Similar results were obtained by ^[19] who found, temperature showed negative correlation with DO ($r = - 0.9$) and positive correlation with pH, nitrate, phosphate and phytoplankton in Narmada River, India.

Table 1: Range Values of River Nile Water Characters During July 2007- January 2009

Parameters	Unit	H1	H2	H3	C1	C2	C3
pH		7.9-8.5	7.8-8.4	8-8.4	8-8.4	7.9-8.5	8-8.8
Turbidity	NTU	2.5-4.8	3.4-12	2.9-7.7	3.2-9.4	3-7.2	1.9-4.7
Temperature	°C	17-30	17-30	17-30	17-30	17-30	17-30
Electric Conductivity	µmohs/Cm	300-430	310-1000	310-400	310-400	300-400	300-400
Total Dissolved Solids	mg/L	180-271	200-680	186-257	185-271	190-268	175-246
Total Alkalinity (CaCO3)	mg/L	120-150	122-160	120-150	120-150	120-150	120-148
Total Hardness (CaCO3)	mg/L	110-156	112-248	110-156	110-156	112-156	110-156
Calcium Hardness (CaCO3)	mg/L	72-80	72-128	72-90	72-90	72-90	72-90
Magnesium Hardness (CaCO3)	mg/L	38-66	32-112	38-72	38-66	38-66	38-66
Ammonia	mgN/L	Nil	Nil	Nil	Nil	Nil	Nil
Nitrite	mgN/L	Nil-0.014	Nil-0.05	Nil-0.02	Nil-0.014	Nil-0.018	Nil-0.006
Nitrate	mgN/L	0.004-0.3	0.05-1.15	0.04-0.26	0.05-0.3	0.04-0.27	0.015-0.3
Total Phosphorus	mgP/L	0.02-0.1	0.05-0.1	0.01-0.09	0.02-0.09	0.02-0.12	0.03-0.09
Dissolved Phosphorus	mgP/L	0.01-0.07	0.004-0.07	0.007-0.09	0.003-0.07	0.003-0.085	0.003-0.085
Orthophosphate	mgP/L	0.015-0.078	0.02-0.085	0.005-0.07	0.01-0.085	0.007-0.085	0.007-0.085
Chloride	mg/L	14-38	14-180	14-38	14-38	14-38	14-38
Dissolved Silica	mg SiO2/L	0.4-2.6	0.34-5.5	0.4-2.5	0.4-3.2	0.4-2.5	0.4-2.5
Sulphate	mg/L	5-30	5.5-148	5.5-20	5.5-30	4.8-30	5.8-30
Iron	mg/L	0.24-0.7	0.14-1.6	0.13-0.7	0.36-0.6	0.36-0.6	0.2-0.5
Manganese	mg/L	0.05-0.45	0.1-0.65	0.05-0.97	0.05-0.54	0.06-0.4	0.04-0.4
Dissolved oxygen	mg O2/L	6.7-9.8	6-8.2	7.2-9.3	7.6-10.3	6.7-10.4	7.2-10.1

Table 2: Correlation Coefficient Between Water Quality Parameters

Variable	Temp.	pH	Turbidity	DO	Chl "a"	NO ₃	PO ₄	SiO ₂	Algal Count
Temp.	1								
pH	+0.55	1							
Turbidity	-0.17	+0.61	1						
DO	-0.88	+0.59	+0.14	1					
Chl "a"	+0.008	-0.19	+0.008	-0.26	1				
NO ₃	+0.78	+0.11	+0.20	+0.64	+0.27	1			
PO ₄	+0.27	-0.30	+0.24	+0.08	+0.52	+0.75	1		
SiO ₂	+0.69	-0.27	-0.21	-0.8	+0.18	-0.73	-0.44	1	
Algal Count	+0.73	+0.65	+0.49	+0.42	+0.42	+0.54	+0.31	-0.28	1

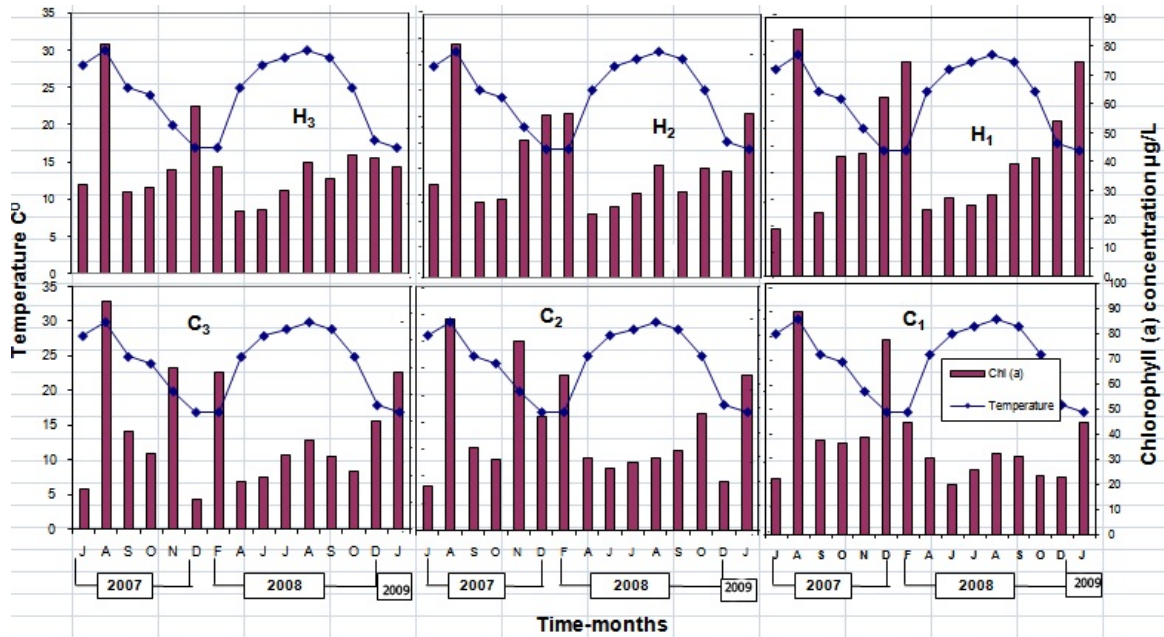


Fig. 2: Relationship Between Chlorophyll (a) Concentration and Temperature Along River Nile.

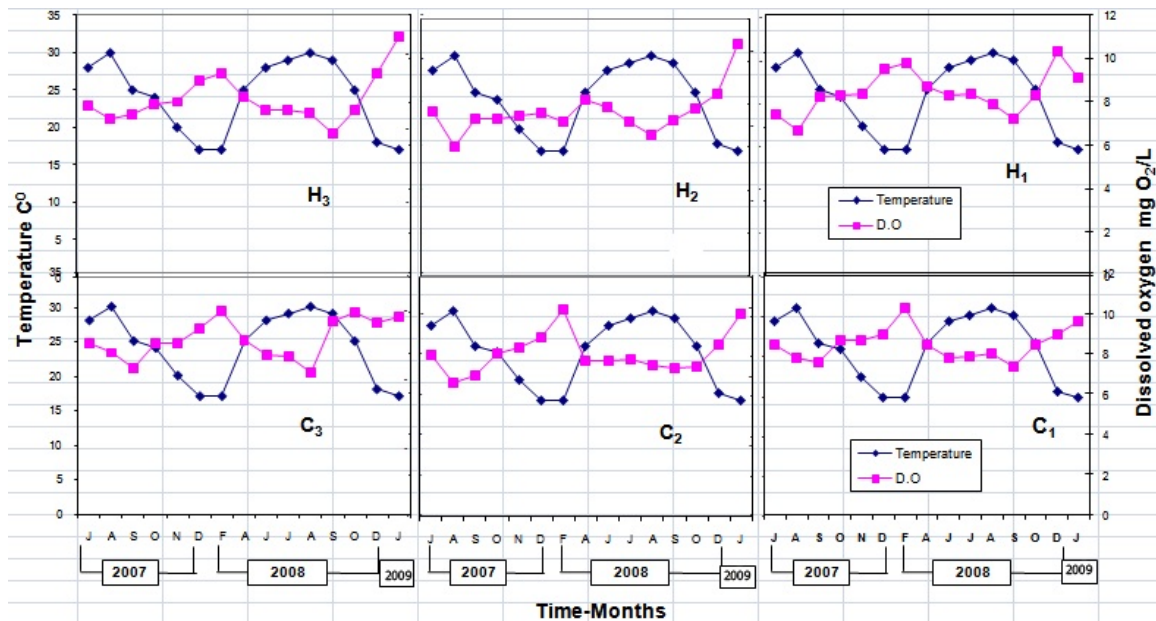


Fig. 3: Relationship Between Dissolved Oxygen and Temperature Along River Nile

2- pH: The pH of the water River Nile during the study period ranged between 7.8- 8.8. The highest value was associated with prevailing algae. Phytoplankton bloom plays an important role in pH value. During algal bloom the pH increase and reached to maximum value 8.8 (Fig.4).

Also, [20] found that , pH values were in alkaline side (7.4 – 9.02) . The increase in pH values during the dense of vegetation and phytoplankton, which were

accompanied by photosynthetic activity and consumption of CO₂ with expected pH elevation [21].

Statistical analysis showed that positive correlation of pH with dissolved oxygen ($r = + 0.59$), also with total algal counts ($r = + 0.65$). In contrast the results recorded by Shraddha Sharma [19] revealed that negative correlation of pH with DO ($r = - 0.8$) in Narmada River, India.

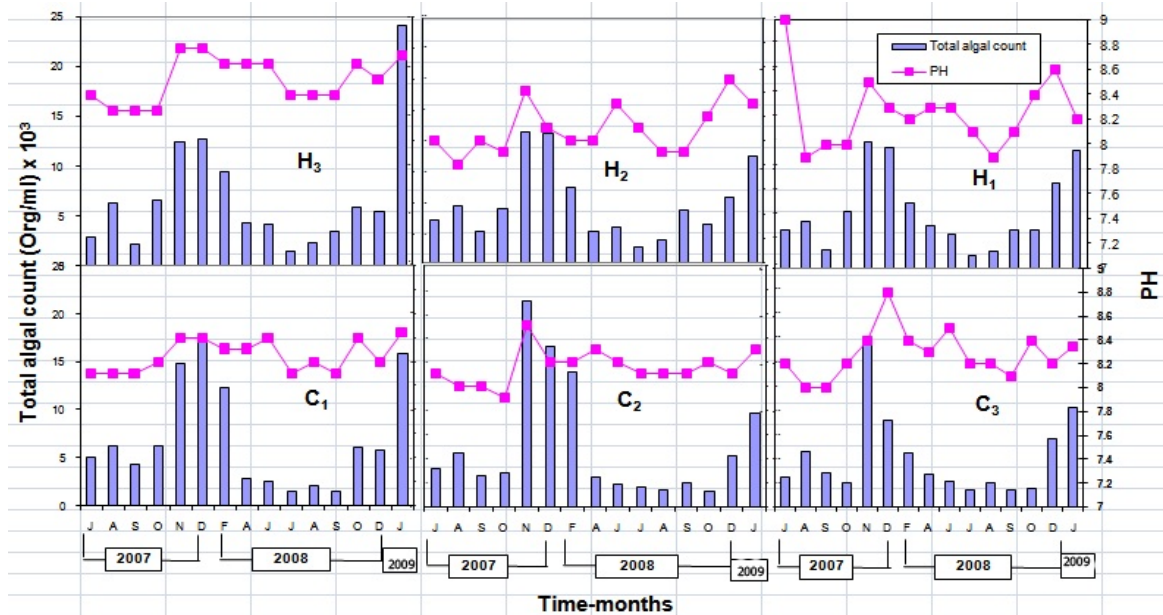


Fig. 4: Relationship Between Total Algal Count and PH Along River Nile.

3- Turbidity: The turbidity level ranged between 1.9 to 12 NTU throughout study period. The highest value was recorded during February 2008, when phytoplanktonic counts were dominated by centric diatoms. Water clarity was improved with creation of the High Dam construction which controls particulate matter by increasing sedimentation. Positive correlation was found between turbidity values and total algal counts (Fig.5). This confirmed by statistical analysis which ($r = +0.94$) between turbidity and algal counts (Table 2).

4- Dissolved Oxygen (DO): Dissolved oxygen in natural water depends on the physical, chemical and biological activities in the water body. The maximum value $10.4 \text{ mgO}_2/\text{L}$ at C_2 and minimum value $6 \text{ mgO}_2/\text{L}$ observed at H_2 (Table1). The WHO (World Health Organization) suggested the standard of DO is $>5 \text{ mgO}_2/\text{L}$. The DO showed positive correlation with phytoplankton counts ($r = +0.49$) and Nitrate ($r = +0.64$) (Table 2). In contrast, the results recorded by [20] showed that, DO was correlated negatively with nitrite, ammonium, but positively with pH. From a biological standpoint, the phytoplankton density in Nile water strongly influences the concentration of dissolved oxygen. Oxygen supersaturation (104%) was observed during winter when phytoplankton especially those belonging to diatoms were abundant (Fig. 6). Similar results were obtained by [3], who found that oxygen supersaturation (112%) was recorded during winter season when planktonic algae were dominated.

5- Phosphate: Phosphorus occurs in natural water almost solely as phosphates. Increased input of inorganic phosphate to lakes, bays and other surface water causes eutrophication. The major source of inorganic phosphorus are domestic sewage, detergent, industrial and agricultural effluents. High phosphate content was recorded 0.12 mg/L at C_2 and minimum 0.01 mg/L at H_3 as shown in (Table 1), this is due to the high algal biomass at Helwan. The phosphate showed positive correlation between phosphorus and phytoplankton counts ($r = +0.31$) (Table 2 and Fig.7). The same results were obtained by [19] who found that positive correlation with phytoplankton counts ($r = +0.3$) in Narmada River. In addition [11] found a statistically significant correlation between chlorophyll "a" and phosphorus concentration in River Nile water. In contrast the results recorded by [20] the statistical analysis showed negative correlation between pH and ortho-P as well as total-P, suggesting that the solubility of phosphorus is dependent on pH [23].

6- Nitrate: Nitrogen in water occurs in various forms like nitrates, nitrites, ammonia and organic nitrogen. Nitrate nitrogen is one of the most important indicators of pollution of water. Nitrate represents the highest oxidized form of nitrogen and used as essential nutrient for phytoplankton growth. Accordingly, the minimum value was 0.004 mg/L when algal counts reached its maximum at H_2 and maximum value was 1.15 mg/L (Table 2 and Fig.8). The WHO (World Health Organization) standard drinking water quality guide line

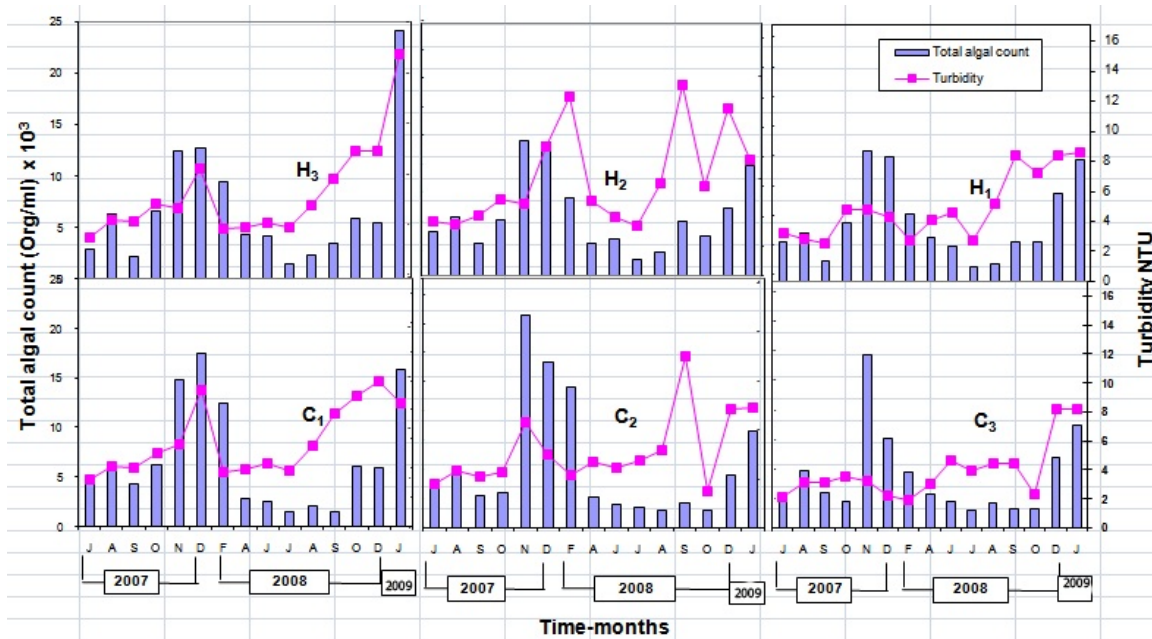


Fig. 5: Relationship Between Total Algal Count and Turbidity Along River Nile

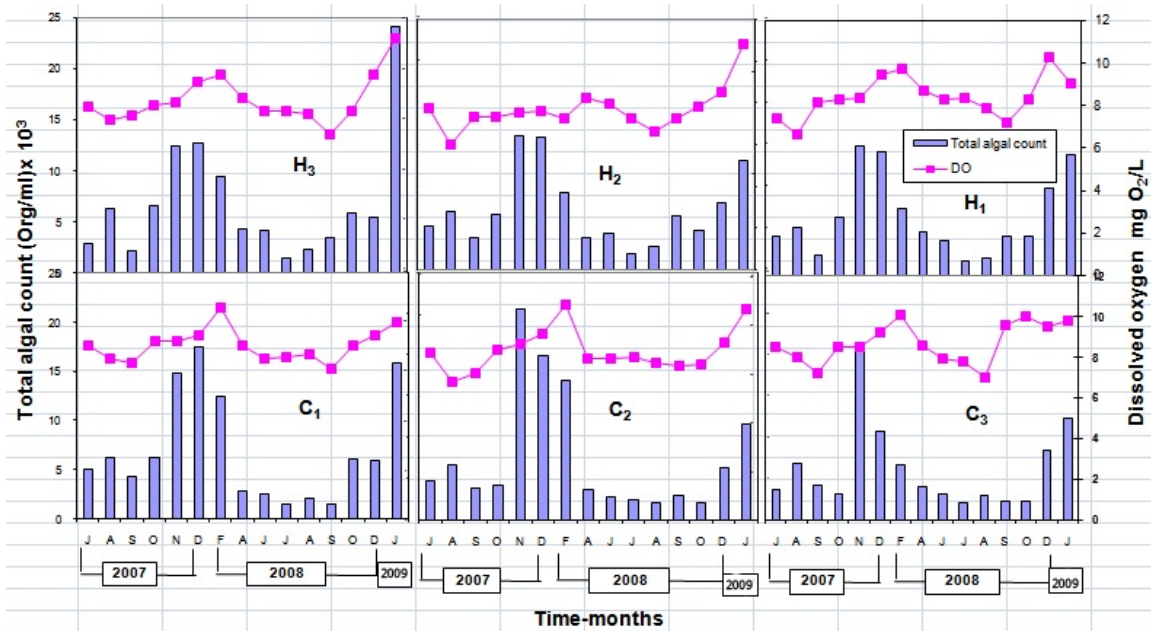


Fig. 6: Relationship Between Total Algal Count And Dissolved Oxygen Along River Nile

for nitrate (NO_3) value is 45 mg/L. Nitrates showed positive correlation with phytoplankton counts ($r = +0.54$). Also, [19] found that, nitrate positive correlation with algal counts ($r = +0.75$) in Narmada River.

7- Silica: Dissolved silica is an important nutrient for formation the silica wall of diatoms (dominate phytoplankton assemblages). Concentration of dissolved

silica ranged between 0.4-5.5 mg/L. The lowest values were associated with maximal growth of phytoplanktonic diatoms. However, there was a significant positive correlation between diatoms and dissolved silica (Fig.9) than other two groups. The same results were obtained by [20] who found that, silicate fluctuated between 0.77 to 6.66 mg/L. The pronounced decrease in silicate of Nile water during

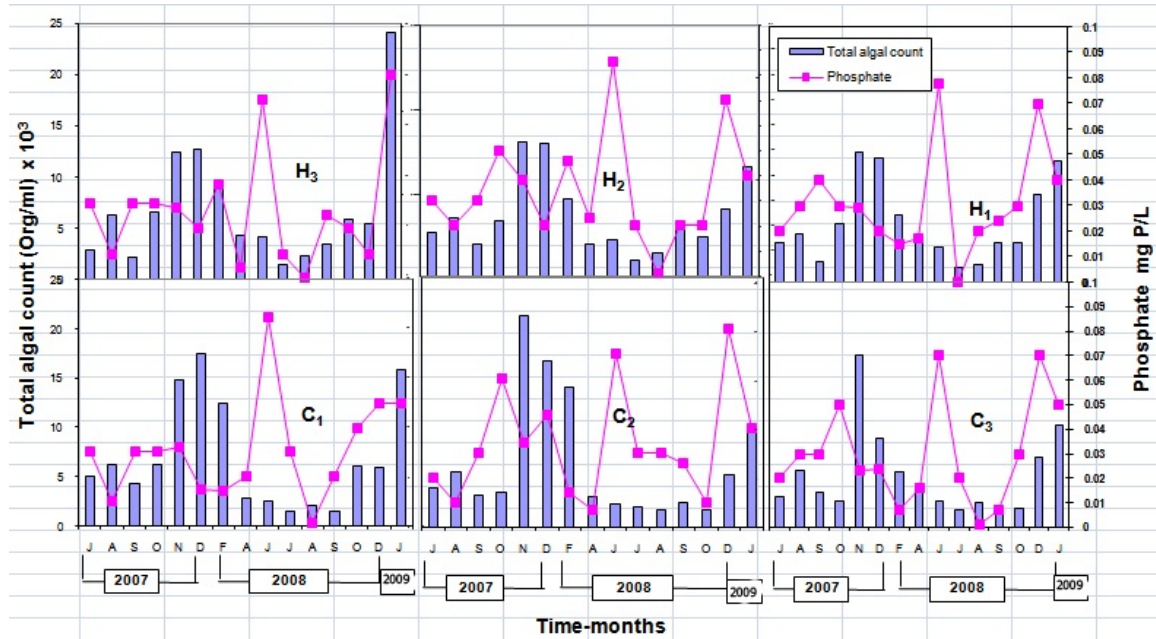


Fig. 7: Relationship Between Total Algal Count and Nitrate Along River Nile

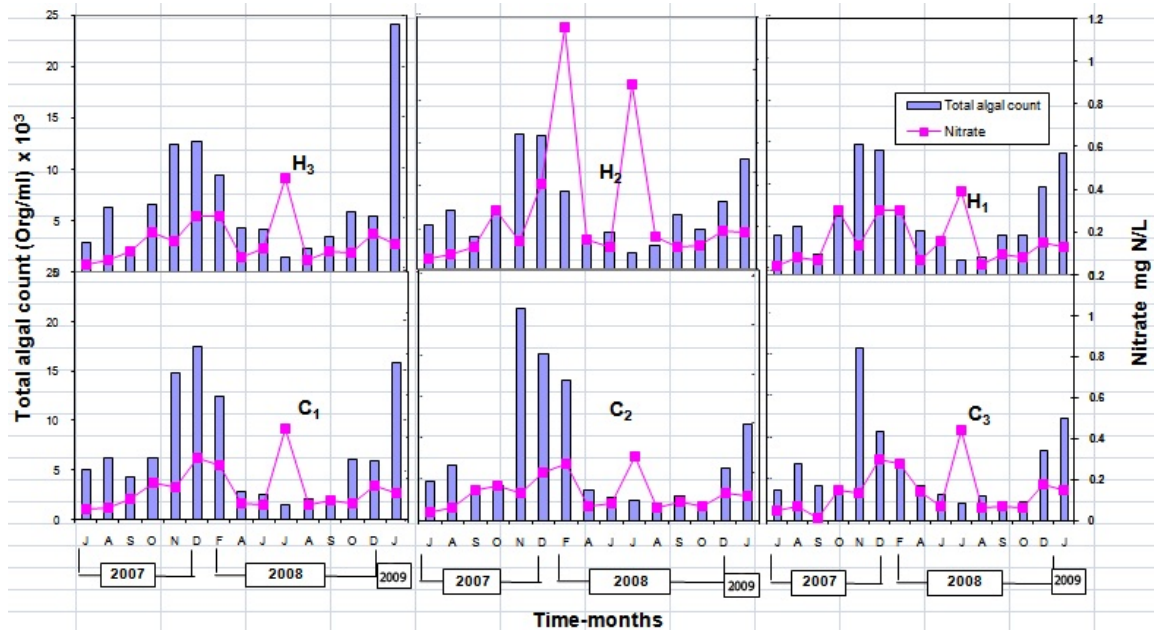


Fig. 8: Relationship Between Total algal Count and Phosphate Along River Nile

winter is related to the low flow discharge of Nile water, in addition to uptake by diatoms blooms ^[22]. Statistically, the dissolved silica in Nile water was negative correlation with algal counts ($r = -0.28$), nitrate ($r = -0.73$), phosphate ($r = -0.44$) and pH ($r = -0.27$) and positive correlation with temperature ($r = +0.69$) (Table 2).

It is important to note that diatoms are the major group of phytoplankton assemblages.

8- Chlorophyll "a" Content: Chlorophyll "a" content ranged from 11.7 – 74.7 $\mu\text{g/L}$. In winter season biomass achieved its maximum. However, good relationship between phytoplankton numbers and chlorophyll "a" content were established (Fig. 10). Statistical analysis showed that positive correlation of Chl "a" with total algal counts ($r = +0.4$), Nitrate ($r = +0.27$) and Phosphate ($r = +0.5$).

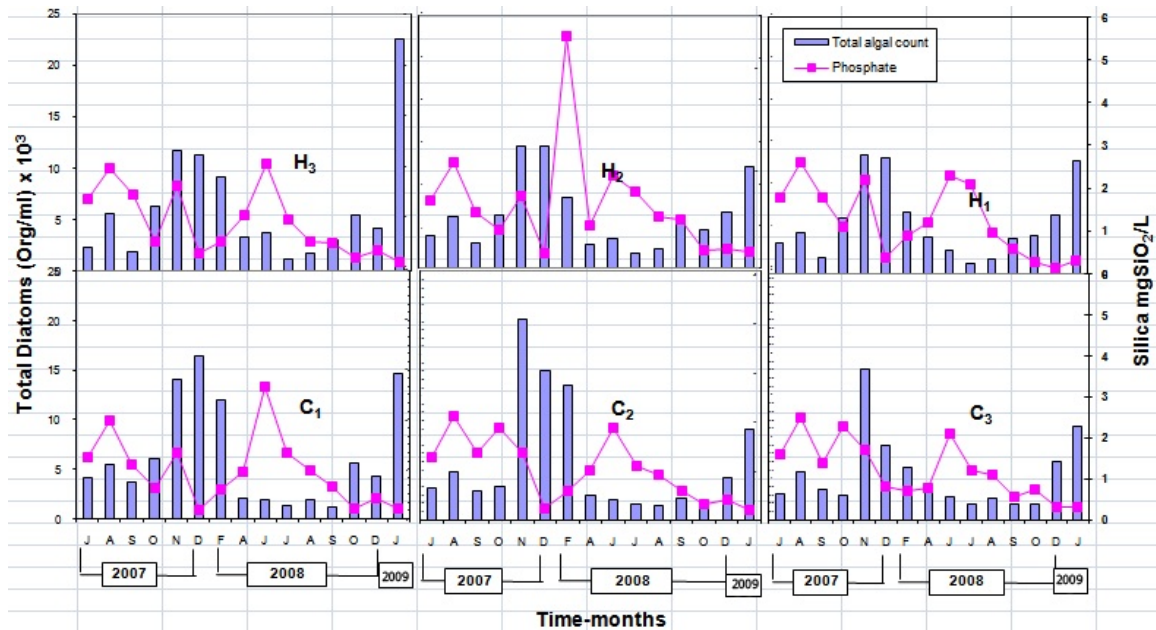


Fig. 9: Relationship Between Diatoms and Silica Along River Nile.

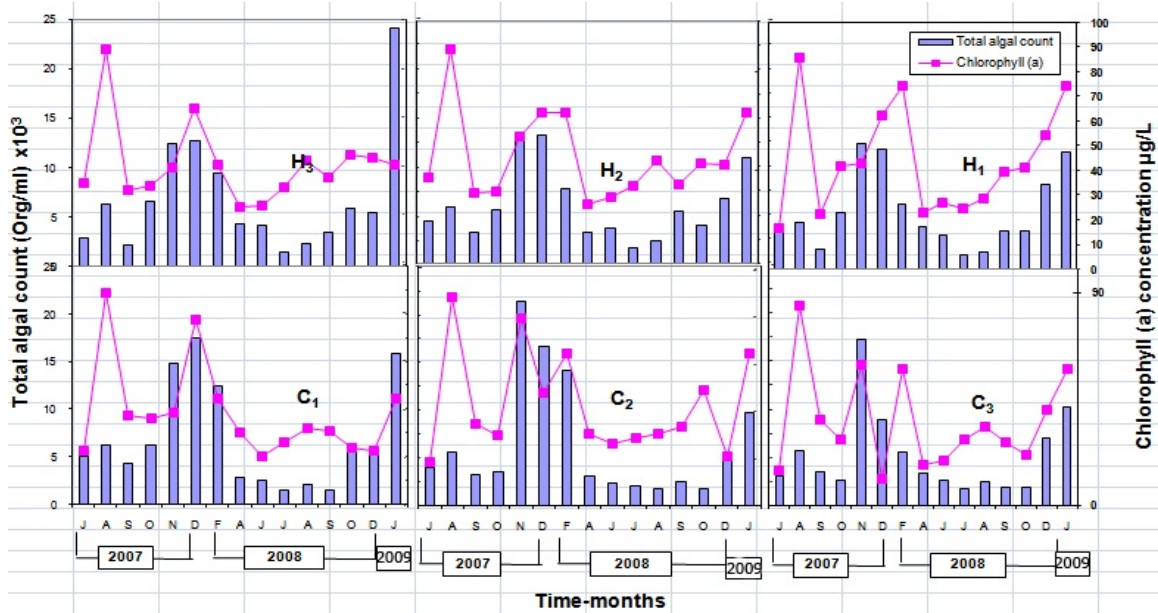


Fig. 10: Relationship Between Total Algal Count and Chlorophyll (a) Concentration Along River Nile.

9- Planktonic Algal Numbers: Clear variability in total algal numbers during different months of the investigated study. The algal counts ranged from 2246 – 21245 Org./ml with maximum attained during winter seasons. The result of statistical analysis showed that, positive correlation of algal counts with temperature ($r = + 0.42$), pH ($r = + 0.65$), turbidity ($r = + 0.49$), DO ($r = + 0.42$), nitrate ($r = + 0.65$) and phosphate ($r = + 0.31$).

Summary: Monitoring the water quality of the River Nile were carried out. Water sample were collected at monthly intervals from six sampling stations located at Cairo district. The results revealed that, positive relationship between algal counts and nutrients was highly significant. Also, most of the water samples were below or limited according to the WHO standards. In general the River Nile water quality was satisfactory and suitable for human consumption and other domestic uses.

Conclusion:

- 1- It can be concluded that, due to Nile water storage by the High-Dam, the physico-chemical characters of River Nile water seem to be affected in some criteria. For example, available nutrients, the high temperature and the low turbidity are prominent examples.
- 2- According to this study, it can be expected that water quality changing tremendously from day to day and even from one place to another.
- 3- Chemical, physical and biological characteristics give a perception of water quality and pollution.
- 4- In general the River Nile water quality was satisfactory and suitable for human consumption and other domestic uses.

REFERENCES

1. Shehata, S.A. and S.A. Badr, 1985. Effect of Nile River water quality on algal distribution at Cairo, Egypt. *Environ. International*, 11: 465-474.
2. Shehata, S.A., M.R. Lasheen, S.A. Badr and A.A. Ashmawy, 1995. Seasonal variation in phytoplankton diversity and metals in sediments of River Nile, Cairo, Egypt. *Egyptian J. App. Sci.*, 10(7): 573-587.
3. Shehata, S.A., S.A. Badr and S.Z. Wahba, 1997. Phytoplankton composition of the River Nile at the Intake of El-Giza Water Works. *Egyptian J. App. Sci.*, 12(12): 389-412.
4. Shehata, S.A., Gamila, H. Ali and S.Z. Wahba, 2008. Distribution pattern of Nile Water Algae with reference to its treatability in drinking water. *J. Appl. Sci. Res.*, 4(6): 722-730.
5. Cloot, A. and LeRoax, 1997. Modelling Algal Blooms in the Middle Vaal River: A site Specific Approach. *Wat. Res.*, 31(2): 271-279.
6. Garret, M.K., S.T.C. Weatherap and M.D.B. Allan, 1978. Algal culture in a liquid phase of animal slurry. Effect of light and temperature upon growth and phosphorus removal. *Environ. Pollut.*, 15: 141-154.
7. Whitton, B.A. and E. Rorr, 1996. Use of algae for monitoring rivers II. Institute für Botanik, Universität Innsbruck. Innsbruck, Austria, pp: 196.
8. Potapova, M., D.F. Charles, 2005. Choice of substrate in algae-based water-quality assessment. *J. N. Am. Benthol. Soc.*, 24: 415-427.
9. Stevenson, J.R., 1983. Effects of current and conditions simulating autogenically changing microhabitats on benthic diatom immigration. *Ecology*, 64: 1514-1524.
10. Peterson, C.G., R.J. Stevenson, 1989. Substratum condition and diatom colonization in difference current regimes. *J. Phycol.*, 25: 790-793.
11. Biggs, B.J.F., R.J. Stevenson, R.L. Lowe, 1998. A habitat matrix conceptual model for stream periphyton. *Archiv FürHydro*, 143: 21-56.
12. Biggs, B.J.F. and R.A. Smith, 2002. Taxonomic richness of stream benthic algae: effect of flood disturbance and nutrients. *Limnol. Oceanogr*, 74: 1175-1186.
13. DeNicola, D.M., 1996. Periphyton responses to temperature at different ecological level. Inc: Stevenson, R. J. Bothwell, M. L., Lowe, R. L. (Eds.). *Algal Ecology of Freshwater Benthic Ecosystem*. Aquatic Ecology Series. Academic Press. Baston, pp: 149-181.
14. Idris, M. and A. Abas, 2005. Trends of physical-chemical water quality in Chini Lake. In M. Idris, K. Hussin & A. L. Mohamnaad (Eds), *Natural resources of Chini Lake* (pp. 20-29). Bangi. Universiti Kebangsaan Malaysia Press.
15. American Public Health Association, 2005. *Standard Methods for the Examination of Water and Wastewater*. APHA, AWWA, WPCE, N. Y. Washington.
16. American Public Health Association, 1965. *Standard Methods for the Examination of Water, Sewage and Industrial Wastes*. APHA, AWWA and WPCF 11th ed. Inc. N. Y.
17. Ezakel, M. and K. Fox, 1957. *Correlation and Regression Analysis*. John Willy & Sons Incorporation, New York.
18. Challerjee, S. and M. Machler, 1995. *Robust Regression: A Weighted Least Squares Approach*, Communications in Statistics, Theory and Methods, 26: 1381-1394.
19. Sharma, S., S. Dixit and P. Jain, 2008. Statistical evaluation of hydrobiological parameters of Narmada River water at Hoshangabad City, India. *Environ. Monit. Assess*, 143: 195-202.
20. Abdel-Satar, M.M., 2005. Water quality assessment of River from Idfo to Cairo. *Egyption Journal of aquatic Research*, 31(2): 200-223.
21. Sabae, S.Z., 2004. Monitoring of microbial pollution in the River Nile and the impact of some human activities on its waters, Proc. 3rd Int. Conf. Biol. Sci. Fac. Sci. Tanta Univ., 28 – 29 April, 3: 200 -214.
22. Elewa, A.A. and M.H. Ghallab, 2000. Water sediment interaction in front of El – Rahawy drain, Rosetta branch, River Nile , Egypt , presented at 4th international Symposium on Sediment quality assessment. Otsu, Japan, October, 24 – 27.
23. Diaz, O.A., K.R. Reddy and Jr, P.A. Moore, 1994. Solubility of inorganic phosphorus in stream water as influenced by pH and Calcium concentration. *Wat. Res.*, 28(8): 1755 -1763.